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(57) Abstract The use of P <sub>2</sub> O <sub>5</sub> and/or B <sub>2</sub> O <sub>3</sub> as a component to improve the refractoriness of inorganic fibres comprising SiO <sub>2</sub> , and CaO and/or MgO is described. The inorganic fibres have a composition such that SiO <sub>2</sub> + P <sub>2</sub> O <sub>5</sub> -(58 + (if MgO > 10, 0.5 x (MgO-10) else 0)) > -2.4 wt.%.			

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## SALINE SOLUBLE INORGANIC FIBRES

This invention relates to saline soluble inorganic fibres.

Saline soluble inorganic fibres have been described in several patent specifications, see for example WO93/15028. Fibres are required to be soluble in saline solution so that inhaled or ingested fibres dissolve rather than providing a source of irritation or otherwise affecting health. WO93/15028 showed that fibres comprising  $\text{SiO}_2$ ,  $\text{CaO}$  and  $\text{MgO}$  and having a silica content of greater than 58% (or greater than 58% plus 0.5 times (wt%MgO - 10) if  $\text{MgO} > 10\text{wt}\%$ ) had suitable shrinkage characteristics at  $800^\circ\text{C}$  and  $1000^\circ\text{C}$  to be usable as refractory materials. A further feature of WO93/15028 was the use of the percentage of non-bridging oxygens present to predict the solubility of fibres in physiological saline solution.

Various subsequent applications have described the effect of  $\text{P}_2\text{O}_5$  and  $\text{B}_2\text{O}_3$  on solubility - see for example WO95/29135.  $\text{P}_2\text{O}_5$  is alleged to have a solubilising effect on such fibres.

The German government have proposed a fibre classification which turns on a variable  $K_1$  which is defined as:

$$K_1 = \Sigma(\text{Na, K, B, Ca, Mg, Ba -oxide}) - 2 * \text{Al-oxide}$$

(the amounts of the oxides being expressed as weight %)

According to the proposed fibre classification if  $K_1$  is greater than 40 the fibre requires no health warnings. If  $K_1$  lies between 30 and 40 the fibre requires health warnings to be made. If  $K_1$  is less than 30 more serious marking is required (it is labelled as a carcinogen). It is readily apparent that it is difficult to provide a high  $K_1$  fibre ( $K_1 > 40$ ) while still providing a refractory fibre like that of WO93/15028 ( $\text{SiO}_2 > 58\text{wt}\%$ ), there being a very narrow window of compositions to meet.

As a result of investigating fibre compositions that may meet the fibre classification and yet still be refractory enough to meet the standard of WO93/15028 (shrinkage of less than 3.5% at both  $800^\circ\text{C}$  and  $1000^\circ\text{C}$ ) the applicants have found that addition of  $\text{P}_2\text{O}_5$  to compositions allows a broader range of refractory fibres to be produced than had previously been appreciated. They have also found that  $\text{B}_2\text{O}_3$ , previously thought to be

extremely detrimental to refractoriness, has a similar, although lesser, effect and that both  $P_2O_5$  and  $B_2O_3$  may be used in the fibres of WO93/15028.

The applicants have found that the refractoriness of the  $P_2O_5$  and  $B_2O_3$  containing fibres of the present invention is dependent on the sum of the amounts of  $SiO_2$  and  $P_2O_5$  (expressed in wt%)

It appears that a further factor that may be important in determining the refractoriness of a fibre is the percentage of non-bridging oxygens. If this percentage is 61.4% or more (calculated on the basis of the amounts of the components  $SiO_2$ ,  $CaO$ ,  $MgO$ ,  $P_2O_5$ , and  $B_2O_3$ ) the fibres tend to fail shrinkage tests at 800°C and 1000°C (failure being defined as a shrinkage of 3.5% or more).

Accordingly the present invention provides the use of  $P_2O_5$  and/or  $B_2O_3$  as a component to improve the refractoriness of inorganic fibres comprising  $SiO_2$ , and  $CaO$  and/or  $MgO$ , the inorganic fibres having a composition such that

$$SiO_2 + P_2O_5 - (58 + (if MgO > 10, 0.5 \times (MgO - 10) else 0)) > -2.4wt\%$$

The invention provides further such fibres in which the percentage of non-bridging oxygens is less than 61.4%.

Further features of the invention are apparent from the claims in the light of the following description.

The percentage of non-bridging oxygens (%N.B.O.) is calculated by converting the weight percentages of  $SiO_2$ ,  $CaO$ ,  $MgO$ ,  $P_2O_5$ , and  $B_2O_3$  to molar amounts and inserting these amounts into the equation:-

$$\%N.B.O. = \frac{2 * (CaO + MgO + P_2O_5 + B_2O_3)}{(2 * SiO_2 + CaO + MgO + 5 \times P_2O_5 + 3 \times B_2O_3)} \times 100$$

The reason the amounts of  $CaO$ ,  $MgO$ ,  $P_2O_5$ , and  $B_2O_3$  are doubled in the numerator to this equation is that each contributes two non-bridging oxygens. The reason terms are multiplied in the denominator to this equation is to reflect the number of oxygen atoms each molecular formula possesses.

Table I shows the results of a first set of shrinkage and solubility tests on compositions comprising  $SiO_2$ ,  $CaO$ ,  $MgO$ ,  $P_2O_5$ , and  $B_2O_3$  as main

ingredients. In this table the analysed compositions are normalised to 100%. It is clear from these compositions that where the percentage of non-bridging oxygens calculated on the basis of the amounts of the above named components is greater than 61.4% (those fibres lying above line A of Table I) the fibres fail the shrinkage tests, having shrinkages of greater than 3.5% at either or both of 800°C and 1000°C.

WO93/15028 stressed the importance of alumina content and the fibres lying between lines B and A of Table I show that alumina contents of greater than 1wt% are damaging to the shrinkage properties of fibres.

The applicants have also found that the combined amount of CaO and MgO is important. Those fibres lying between lines C and B have a combined CaO and MgO content of greater than 42wt% and also fail the shrinkage tests.

The fibres below line C have a percentage of non-bridging oxygens less than 61.4%, an alumina content of less than 1wt%, and a combined CaO and MgO content of less than 42wt%. All of these fibres pass the shrinkage tests. These fibres fall within the compositional ranges:-

SiO <sub>2</sub>	52.4 - 57.85wt%
CaO	22.2 - 39.4wt%
MgO	1.96 - 17.4wt%
P <sub>2</sub> O <sub>5</sub>	0.82 - 7.8wt%
B <sub>2</sub> O <sub>3</sub>	0 - 1.95wt%
Al <sub>2</sub> O <sub>3</sub>	<1wt%

The solubility results presented in Table I were obtained by the methods described in WO93/15028 and show a high solubility for all of the fibres produced.

It can be seen that all of the fibres below line C have a K<sub>I</sub> of more than 35 and more than half have a K<sub>I</sub> of more than 40.

Further testing resulted in the data presented in Table II. The data presented are as in table I but an additional column entitled deviation shows the result of looking to the difference between the sum of the SiO<sub>2</sub> and P<sub>2</sub>O<sub>5</sub> contents and the SiO<sub>2</sub> amount predicted to be needed by WO93/15028 for a fibre to be refractory (shrinkage of less than 3.5% at both 800°C and 1000°C. The figure given is found by calculating the sum

$\text{SiO}_2 + \text{P}_2\text{O}_5 - (58 + (\text{if MgO} > 10, 0.5 \times (\text{MgO} - 10) \text{ else } 0))$

If this is less than -2.4wt% the fibres fail. The fibres that failed are shown in plain text, those that passed in bold text, and those that were difficult to form in italics.

More than 12.5wt%  $\text{P}_2\text{O}_5$  is undesirable as it causes difficulties in making the fibres.

While the above description and the claims refer to  $\text{P}_2\text{O}_5$ ,  $\text{B}_2\text{O}_3$ ,  $\text{SiO}_2$ ,  $\text{CaO}$  and  $\text{MgO}$  it will be clear to the person skilled in the art that the pure materials need not be used and that provision of these components in combined form (e.g. provision of  $\text{P}_2\text{O}_5$  in the form of mixed oxide phosphates) is part of the invention.

Table I

Code	Chemical Composition (XRF - Weight percent)												KI		Sinterage		Solubility (gms)				CaO+MgO	% N.B.O.
	CaO	MgO	P2O5	SiO2	Al2O3	Na2O	K2O	B2O3	F2O3	ZrO2	SrO	800°C	1000°C	CaO	MgO	SiO2	B2O3	Total				
LTP	24.95	19.18	3.41	51.69	0.25	0.30	0.05		0.17	<0.05	<0.05	44.0	40.0	53	98	177		328	44.14	68.5%		
LTP8	24.81	18.66	3.10	50.42	0.38	0.31	<0.05		0.17	0.15	<0.05	43.0	23.9	59	115	193		367	43.47	68.1%		
LTP9	25.13	19.07	2.51	52.34	0.28	0.25	0.05		0.17	<0.05	<0.05	43.9	46.8	55	94	174		355	44.20	68.0%		
LTP11	31.83	12.27	3.39	51.39	0.26	0.42	0.06		0.17	<0.05	<0.05	44.1	49.1	79	76	200		355	44.11	66.1%		
LTP16	24.48	17.89	2.48	54.46	0.21	0.28	0.05		0.16	<0.05	<0.05	42.3	3.62	58	90	169		317	42.37	64.7%		
LTP4	24.04	17.78	3.31	53.85	0.31	0.26	0.05		0.15	0.25	<0.05	41.5	3.71	56	95	180		331	41.83	64.3%		
LTP5	24.22	17.17	4.91	52.72	0.33	0.30	<0.05		0.14	0.21	<0.05	41.0	3.63	65	106	191		362	41.40	64.1%		
LTP17	38.39	5.54	3.41	51.22	0.40	0.42	0.07		0.16	0.38	<0.05	43.6	45.2	83	32	191		306	43.94	63.9%		
LTP23	38.62	5.56	2.57	52.23	0.34	0.46	0.07		0.15	<0.05	<0.05	44.0	42.90	82	29	199		310	44.18	63.7%		
LTP14	30.93	11.01	4.90	51.96	0.30	0.45	0.05		0.15	0.25	<0.05	41.8	3.24	78	69	191		338	41.95	63.0%		
LTP13	11.28	27.95	3.26	57.2	<0.05	0.13	<0.05		0.17	<0.05	<0.05	39.4	5.72	30	117	188		335	39.23	63.0%		
LTP12	30.93	11.35	3.36	53.52	0.32	0.31	0.06		0.15	<0.05	<0.05	42.0	2.55	82	72	207		361	42.27	62.6%		
LTP20	31.05	11.35	2.52	54.14	0.32	0.31	0.06		0.16	0.10	<0.05	42.1	3.38	85	71	200		356	42.40	62.6%		
LTP15	36.89	5.70	5.05	51.22	0.31	0.43	0.10		0.16	0.13	<0.05	42.5	3.41	88	35	204		327	42.59	62.2%		
LTP3	22.89	16.69	6.70	52.38	0.25	0.29	<0.05		0.14	0.46	<0.05	39.4	23.3	43	166	141		350	39.58	61.9%		
LTP7	10.37	27.85	3.29	58.18	<0.05	0.15	<0.05		0.16	<0.05	<0.05	38.4	10.9	36	132	152		320	38.23	61.4%		
LTP52	24.9	11.5	4.89	54.8	2.06	0.28	0.05	<0.05	1.38	<0.05	<0.05	32.6	32.1	72	74	140		286	36.40	56.0%		
LTP51	28.7	11	1.62	56.6	1.38	0.29	0.07	<0.05	0.26	<0.05	<0.05	37.3	3.07	82	69	159		310	39.70	58.4%		
LTP29	40.29	2.09	1.23	55.09	0.43	0.39	0.12		0.19	0.17	<0.05	42.0	45.9	76	10	206		292	42.38	58.8%		
LTP21	36.62	5.58	2.54	54.19	0.39	0.46	0.07		0.15	<0.05	<0.05	42.0	35.5	58	34	208		300	42.20	60.3%		
LTP20	39.40	1.96	2.22	55.25	0.45	0.41	0.10		0.21	<0.05	<0.05	41.0	1.74	72	11	209		292	41.36	57.5%		
LTP41	31.36	9.48	0.85	55.63	0.27	0.30	0.07	1.88	0.16	<0.05	<0.05	42.5	1.20	87	60	194	20	361	40.84	60.0%		
LTP6	29.83	10.45	3.34	55.65	0.21	0.32	0.05		0.15	<0.05	<0.05	40.2	1.89	65	52	172		289	40.28	59.0%		
LTP34	30.44	9.81	1.68	57.3	0.25	0.31	0.07		0.15	<0.05	<0.05	40.1	1.40	76	51	188		315	40.25	58.0%		
LTP43	30.51	9.68	1.68	56.19	0.28	0.32	0.07	1.11	0.15	<0.05	<0.05	41.1	0.97	62	66	187	12	327	40.19	58.8%		
LTP42	30.55	9.56	0.86	57.13	0.27	0.33	0.07	1.08	0.15	<0.05	<0.05	41.1	1.04	75	65	192	12	344	40.12	58.2%		
LTP47	22.2	17.4	3.98	55.2	0.31	0.31	0.05	<0.05	0.1	<0.05	<0.05	39.3	1.97	58	104	197		359	39.60	61.0%		
LTP38	34.82	4.73	0.82	57.84	0.31	0.30	0.08	0.94	0.15	<0.05	<0.05	40.3	1.07	83	25	175	9	292	39.56	55.4%		
LTP2	23.35	16.10	4.87	54.25	0.46	0.24	<0.05		0.16	0.58	<0.05	38.8	2.24	53	96	167		316	39.45	60.8%		
LTP39	34.35	4.73	1.67	57.39	0.27	0.30	0.08	1.06	0.14	<0.05	<0.05	40.0	1.47	32	33	203	16	284	39.08	55.2%		
LTP1	23.29	15.66	3.33	57.01	0.24	0.22	0.06		0.14	<0.05	0.05	38.7	1.31	63	89	175		327	38.94	58.7%		
LTP48	32	6.87	7.8	52.4	0.52	0.34	0.05	<0.05	0.15	0.18	<0.05	38.2	1.24	84	48	205		337	38.87	57.7%		
LTP40	33.67	4.75	0.86	57.85	0.38	0.31	0.08	1.95	0.15	<0.05	<0.05	40.0	1.15	40	32	194	25	291	38.42	54.5%		
LTP26	33.69	4.56	3.73	56.95	0.36	0.43	0.06		0.14	0.07	<0.05	38.0	1.22	91	28	193		312	38.25	54.0%		
LTP27	28.91	9.33	3.66	57.32	0.22	0.36	0.05	<0.05	0.14	<0.05	<0.05	38.2	0.99	67	48	173		288	38.24	55.5%		
LTP46	28.4	8.69	2.67	59	0.29	0.33	0.06	<0.05	0.13	<0.05	<0.05	36.9	0.91	71	46	175		292	37.09	53.3%		



TABLE II (Part I)

Code	Chemical Composition (XRF - Weight percent)										KI	Sinterage			Solubility (ppm)				% N.B.O.		
	CaO	MgO	P2O5	SiO2	Al2O3	Na2O	K2O	B2O3	Fe2O3	ZrO2		SiO	800°C	1000°C	Deviation	CaO	MgO	SiO2		B2O3	Total
LTP																					
LTP8	24.95	19.18	3.41	51.69	0.25	0.30	0.05		0.17			43.99	40.00	-7.49	53	98	177		328	44.14	68.5%
LTP11	25.13	19.07	2.51	52.54	0.28	0.25	0.05		0.17			43.94	46.80	-7.48	55	94	174		323	44.20	68.0%
LTP49	32.35	6.74		50.54	0.57	0.40	0.08	9.17	0.14			47.60	2.65	-7.46	79	41	214	129	463	39.09	62.1%
LTP9	24.81	18.66	5.10	50.42	0.38	0.31			0.17	0.15		43.03	23.90	-6.81	59	115	193		367	43.47	68.1%
LTP67	15.17	25.18	5.06	54.00	0.19	0.25			0.15			40.22	5.70	-6.53							64.9%
LTP13	11.28	27.95	3.26	57.20		0.13			0.17			39.36	5.72	-6.51	30	117	188		335	39.23	63.0%
LTP62	14.99	24.54	2.52	57.24	0.35	0.19			0.16			39.02	4.48	-5.51	25	66	119		210	39.53	62.3%
LTP7	10.37	27.85	3.29	58.18		0.15			0.16			38.37	10.90	-5.46	36	132	152		320	38.23	61.4%
LTP10	24.48	17.89	2.48	54.46	0.21	0.28	0.05		0.16			42.28	3.62	-5.01	58	90	169		317	42.37	64.7%
LTP4	24.04	17.78	3.31	53.85	0.31	0.26	0.05		0.15	0.25		41.52	3.71	-4.73	56	95	180		331	41.83	64.3%
LTP16	31.83	12.27	3.39	51.59	0.26	0.42	0.06		0.17			44.07	49.10	-4.15	79	76	200		355	44.11	66.1%
LTP5	24.22	17.17	4.91	52.72	0.33	0.30			0.14	0.21		41.04	3.63	-3.96	65	106	191		362	41.40	64.1%
LTP59	32.13	10.47	12.93	41.37	2.31	0.56	0.05		0.17			38.59	43.20	-3.94	42	41	179		262	42.60	69.3%
LTP50	31.00	10.40		54.50	0.36	0.31	0.08	3.19	0.16			44.26	29.80	-3.70	79	58	200	30	367	41.40	62.0%
LTP17	38.39	5.54	3.41	51.22	0.40	0.42	0.07		0.16	0.38		43.62	45.20	-3.37	83	32	191		306	43.94	63.9%
LTP56	34.38	9.46	14.72	40.02	0.72	0.55			0.16			42.95	9.98	-3.26	60	57	196		313	43.84	70.5%
LTP23	38.62	5.56	2.57	52.23	0.34	0.46	0.07		0.15			44.03	42.90	-3.20	82	29	199		310	44.18	63.7%
LTP57	34.73	9.55	19.83	35.24	0.23	0.26			0.15			44.08	-	-2.93					0	44.28	71.0%
LTP70	24.38	14.20		57.52	0.44	0.18	0.08	3.01	0.18			40.97	3.63	-2.58	75	73	255	21	424	38.58	58.7%
LTP63	14.61	22.87	2.53	59.45	0.27	0.12			0.16			37.06	9.57	-2.46	17	108	83		208	37.48	58.4%
Above here compositions have deviation of more than 2.4wt%																					
LTP54	29.40	8.73	14.55	46.68	0.07	0.44			0.13			38.43	-	3.23						38.13	60.1%
LTP61	32.46	9.86	14.02	42.67	0.09	0.70	0.05		0.15			42.89	3.44	-1.31						42.32	67.4%
LTP60	31.46	9.58	12.64	44.91	0.69	0.54	0.05		0.14			40.25	-	-0.45						41.04	64.8%
Above here compositions have P2O5 content more than 12.5wt%																					
LTP52	24.93	11.52	4.90	54.88	2.06	0.28	0.05		1.38			32.66	32.10	-	72	74	140		286	36.45	56.1%
LTP51	28.72	11.01	1.62	56.65	1.38	0.29	0.07		0.26			37.33	3.07	-0.24	82	69	159		310	39.73	58.4%
Above here fibres have Al2O3 content above 1 wt%																					
LTP15	36.89	5.70	5.05	51.22	0.31	0.43	0.10		0.16	0.13		42.50	3.41	-1.72	88	35	204		327	42.59	62.2%
LTP14	30.93	11.01	4.90	51.96	0.30	0.45	0.05		0.15	0.25		41.85	3.24	-1.65	78	69	191		338	41.95	63.0%
LTP58	32.93	9.77	12.01	44.34	0.19	0.53	0.05		0.19			42.90	2.62	-1.65	57	42	223		322	42.70	67.9%
LTP55	32.58	9.47	9.65	46.79	0.04	0.46	0.05		0.17			40.88	1.72	-1.56	71	54	203		328	42.05	65.1%
LTP53	29.34	9.84	9.58	50.26	0.17	0.56	0.05		0.15	0.05		39.45	0.81	1.84	71	83	223		376	39.18	60.1%
Above here SiO2 content less than 52wt%																					

TABLE II (Part 2)

Code	Chemical Compositions (XRF - Weight percent)												KI	Shrinkage			Solubility (ppm)			CaO+MgO	% N.B.O.		
	CaO	MgO	P2O5	SiO2	Al2O3	Na2O	K2O	B2O3	Fe2O3	ZrO2	SO	800°C		1000°C		Deviation	CaO	MgO	SiO2			B2O3	Total
												23.30		29.50	23.30					29.50			
LTP1	22.89	16.69	6.70	52.58	0.25	0.29			0.14	0.46		39.37	23.30	29.50	-2.07	43	166	141		350	61.9%		
LTP3	31.05	11.35	2.52	54.14	0.32	0.31	0.06		0.16	0.10		42.13	3.38	29.70	-2.01	85	71	200		356	62.6%		
LTP20	23.35	16.10	4.87	54.25	0.46	0.24			0.16	0.58		38.77	2.24	3.05	-1.93	53	96	167		316	60.8%		
LTP2	30.93	11.35	3.36	53.52	0.32	0.31	0.06		0.15			42.00	2.55	30.10	-1.79	82	72	207		361	62.6%		
LTP12	36.62	5.58	2.54	54.19	0.39	0.46	0.07		0.15			41.95	-	35.50	-1.27	58	34	208		300	60.3%		
LTP21	31.90	6.85	7.78	52.24	0.52	0.34	0.05		0.15	0.18		38.10	1.24	1.53	2.02	84	48	205		337	57.7%		
Above here SiO2 content 52wt% to less than 55wt%																							
LTP47	22.30	17.48	4.00	55.45	0.31	0.31	0.05		0.10			39.52	1.97	2.14	-2.29	58	104	197		359	61.0%		
LTP64	20.81	18.41	2.52	57.63	0.22	0.26			0.14			39.04	3.01	3.73	-2.05	46	76	197		319	59.7%		
LTP68	20.08	18.77	4.55	55.92	0.30	0.24			0.14			38.49	3.90	4.16	-1.92	51	89	226		366	60.2%		
LTP29	40.29	2.09	1.23	55.09	0.43	0.39	0.12		0.19	0.17		42.03	45.85	-	-1.68	76	10	206		292	58.8%		
LTP41	31.36	9.48	0.85	55.63	0.27	0.30	0.07	1.88	0.16			42.55	1.20	2.32	-1.52	87	60	194	20	361	60.0%		
LTP71	38.31	0.65		56.51	0.55	0.20	0.09	3.54	0.14			41.69	0.59	1.43	-1.49	73	2	278	55	408	54.9%		
LTP30	39.40	1.96	2.22	55.25	0.45	0.41	0.10		0.21			40.96	1.74	2.04	-0.53	72	11	209		292	57.5%		
LTP1	23.29	15.66	3.33	57.01	0.24	0.22	0.06		0.14		0.05	38.74	1.31	1.77	-0.49	63	89	175		327	58.7%		
LTP43	30.51	9.68	1.68	56.19	0.28	0.32	0.07		0.15			41.13	0.97	1.84	-0.12	62	66	187	12	327	58.8%		
LTP37	35.40	4.77		57.92	0.31	0.31	0.09		0.15			40.99	1.57	2.13	-0.08	37	30	195	13	275	56.1%		
LTP32	30.01	8.53		57.95	0.32	0.23	0.09		0.18			40.92	1.68	2.83	-0.05	80	46	184	24	334	56.3%		
LTP73	36.93	0.61		57.96	0.49	0.23	0.09		0.13			40.43	1.23	3.00	-0.04	76	2	264	40	382	52.6%		
LTP42	30.55	9.56	0.86	57.13	0.27	0.33	0.07		0.15			41.06	1.04	1.81	-0.02	75	65	192	12	344	58.2%		
LTP38	34.82	4.73	0.82	57.84	0.31	0.30	0.08		0.15			40.26	1.07	1.40	0.66	83	25	175	9	292	55.4%		
LTP40	33.67	4.75	0.86	57.85	0.38	0.31	0.08		0.15			40.00	1.15	2.39	0.71	40	32	194	25	291	54.5%		
LTP6	29.83	10.45	3.34	55.65	0.21	0.32	0.05		0.15			40.23	1.89	2.76	0.76	65	52	172	289	289	59.0%		
LTP69	19.17	17.56	4.66	57.93	0.31	0.23			0.13			36.34	1.23	1.68	0.81	49	88	241		378	56.5%		
LTP34	30.44	9.81	1.68	57.30	0.25	0.31	0.07		0.15			40.13	1.40	1.79	0.98	76	51	188		315	58.0%		
LTP39	34.35	4.73	1.67	57.39	0.27	0.30	0.08		0.14			39.98	1.47	1.93	1.06	32	33	203	16	284	55.2%		
LTP26	33.69	4.56	3.73	56.95	0.36	0.43	0.06		0.14	0.07		38.02	1.22	1.40	2.68	91	28	193		312	54.0%		
LTP27	28.91	9.33	3.66	57.32	0.22	0.36	0.05		0.14			38.21	0.99	1.16	2.99	67	48	173		288	55.5%		
Above here SiO2 content 55wt% to less than 58wt%																							

TABLE II (Part 3)

Code	Chemical Composition (XRF - Weight percent)													KI		Shrinkage		Solubility (ypm)				CaO+MgO	% N.B.O.
	CaO	MgO	P2O5	SiO2	Al2O3	Na2O	K2O	B2O3	Fe2O3	ZrO2	SO	800°C	1000°C	Deviation	CaO	MgO	SiO2	B2O3	Total				
LTP	15.65	21.16	4.38	58.17	0.24	0.25			0.15			36.58	2.65	3.19	-1.03	39	84	169		283	36.81	57.7%	
LTP66	20.36	17.74	2.50	58.75	0.30	0.22			0.13			37.72	2.28	2.37	-0.62	41	68	185		294	38.10	57.6%	
LTP65	22.67	13.60		59.64	0.37	0.27	0.06	3.25	0.14			39.11	3.37	6.16	-0.16	49	56	197	23	325	36.27	55.0%	
LTP72	32.72	4.76		58.60	0.28	0.31	0.08	3.09	0.15			40.40	1.65	3.85	0.60	88	26	179	29	322	37.48	53.5%	
LTP31	28.30	9.20		58.70	0.28	0.29	0.06	3.00	0.18			40.29	3.15	4.88	0.70	91	60	205	31	387	37.50	55.1%	
LTP36	33.37	4.82		58.90	0.27	0.30	0.08	2.10	0.15			40.13	1.50	3.12	0.90	37	33	198	25	293	38.19	53.9%	
LTP33	30.20	9.03		59.01	0.27	0.28	0.08	0.96	0.17			40.02	2.16	2.74	1.01	88	52	193	10	343	39.23	56.1%	
LTP44	29.05	6.88		59.81	0.35	0.36	0.07	3.16	0.13	0.19		38.82	1.60	2.71	1.81	89	44	193	32	358	35.93	52.1%	
LTP45	24.10	11.40		62.48	0.54	0.24	0.06	1.04	0.15			35.76	2.17	3.15	3.78	81	65	189	10	345	35.50	51.3%	
LTP46	28.52	8.73	2.68	59.25	0.29	0.33	0.06		0.13			37.06	0.91	0.99	3.93	71	46	175		292	37.25	53.3%	

Above here SiO2 content 58 wt% or more

Above bare SiO<sub>2</sub> content 58wt% or more

CLAIMS

1. The use of  $P_2O_5$  or  $B_2O_3$  as a component to improve the refractoriness of inorganic fibres comprising  $SiO_2$ , and CaO and/or MgO, to produce inorganic fibres having a composition having a shrinkage of less than 3.5% when exposed to 1000°C for 24 hours and having a shrinkage of less than 3.5% when exposed to 800°C for 24 hours, the fibres having a composition such that

$$SiO_2 + P_2O_5 - (58 + (\text{if } MgO > 10, 0.5 \times (MgO - 10) \text{ else } 0)) > -2.4wt\%$$

2. The use of  $P_2O_5$  or  $B_2O_3$  as a component to improve the refractoriness of inorganic fibres as claimed in claim 1 in which the percentage of non-bridging oxygens is less than 61.4%.
3. The use of  $P_2O_5$  or  $B_2O_3$  as a component to improve the refractoriness of inorganic fibres as claimed in claim 1 or claim 2 in which the fibres fall within the compositional range:-

$SiO_2$	44 or more
CaO	20 - 40wt%
MgO	0 - 18wt%
$P_2O_5$	0 - 12.5wt%
$B_2O_3$	0 - 4wt%

4. The use of  $P_2O_5$  or  $B_2O_3$  as a component to improve the refractoriness of inorganic fibres as claimed in claim 3 in which the fibres fall within the compositional range:-

$SiO_2$	52 - <58wt% [52 - <58+0.5'(MgO-10)wt% if MgO > 10wt%]
CaO	22 - 40wt%
MgO	0 - 17.5wt%
MgO + CaO	< 42wt%
$P_2O_5$	0.5 - 10wt%
$B_2O_3$	0 - 2wt%

5. The use of  $P_2O_5$  or  $B_2O_3$  as a component to improve the refractoriness of inorganic fibres as claimed in claim 3 in which the fibres fall within the compositional range:-

$SiO_2$	44.34 - 62.48
---------	---------------

CaO	20.36 - 39.4wt%
MgO	0.62 - 21.16wt%
P <sub>2</sub> O <sub>5</sub>	0 - 12.01wt%
B <sub>2</sub> O <sub>3</sub>	0 - 3.54wt%

6. Saline soluble inorganic fibres having a shrinkage of less than 3.5% when exposed to 1000°C for 24 hours and having a shrinkage of less than 3.5% when exposed to 800°C for 24 hours, in which:-

$$\text{SiO}_2 + \text{P}_2\text{O}_5 - (58 + (\text{if MgO} > 10, 0.5 \times (\text{MgO} - 10) \text{ else } 0)) > -2.4\text{wt}\%$$

7. Saline soluble inorganic fibres as claimed in claim 6 comprising:-

SiO <sub>2</sub>	44 or more
CaO	20 - 40wt%
MgO	0 - 18wt%
P <sub>2</sub> O <sub>5</sub>	0 - 12.5wt%
B <sub>2</sub> O <sub>3</sub>	0 - 4wt%

8. Saline soluble inorganic fibres as claimed in claim 7 comprising:-

SiO <sub>2</sub>	52 - <58wt% [52 - <58+0.5'(MgO-10)wt% if MgO > 10wt%]
CaO	22 - 40wt%
MgO	0 - 17.5wt%
MgO + CaO	< 42wt%
P <sub>2</sub> O <sub>5</sub>	0.5 - 10wt%
B <sub>2</sub> O <sub>3</sub>	0 - 2wt%

and in which the percentage of non-bridging oxygens calculated on the basis of the amounts of the above named components is less than 61.4%.

9. Saline soluble inorganic fibres as claimed in claim 7 comprising:-

SiO <sub>2</sub>	44.34 - 62.48
CaO	20.36 - 39.4wt%
MgO	0.62 - 21.16wt%
P <sub>2</sub> O <sub>5</sub>	0 - 12.01wt%
B <sub>2</sub> O <sub>3</sub>	0 - 3.54wt%

10. Saline soluble inorganic fibres as claimed in claim 6 in which the fibres have a composition:-

SiO <sub>2</sub>	52.4 - 57.85wt%
CaO	22.2 - 39.4wt%
MgO	1.96 - 17.4wt%
P <sub>2</sub> O <sub>5</sub>	0.82 - 7.8wt%
B <sub>2</sub> O <sub>3</sub>	0 - 1.95wt%
Al <sub>2</sub> O <sub>3</sub>	<1wt%

# INTERNATIONAL SEARCH REPORT

Internal Application No  
PCT/GB 97/01667

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 C03C13/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 C03C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 93 22251 A (SAINT GOBAIN ISOVER ;HOLSTEIN WOLFGANG (DE); LOHE PETER (DE); SCHW) 11 November 1993 see page 1, line 37 - page 3, line 36; example 6 ---	1-3,5-7, 9
X	WO 89 12032 A (MANVILLE SALES CORP) 14 December 1989 see page 9, paragraph 3 - page 10, paragraph 2; examples 164,166-170 ---	1-3,6,7
X	DE 44 17 230 A (GRUENZWEIG & HARTMANN) 23 November 1995 see example 2 --- -/-	1,2,6

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

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Date of mailing of the international search report

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Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Van Bommel, L

# INTERNATIONAL SEARCH REPORT

Internat. Application No  
PCT/GB 97/01667

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 93 15028 A (MORGAN CRUCIBLE CO) 5 August 1993 cited in the application see page 7, paragraph 4 - page 9, paragraph 3; examples ----	6,7
X	WO 92 09536 A (PAROC OY AB) 11 June 1992 see example C ----	6
A	WO 96 01793 A (ROCKWOOL AB ;PERANDER MICHAEL (FI); ROENNLOEF BJOERN (FI)) 25 January 1996 see page 5, line 28 - page 7, line 10 ----	1-10
A	WO 95 29135 A (ROCKWOOL INT ;JENSEN SOREN LUND (DK); CHRISTENSEN VERMUND RUST (DK) 2 November 1995 cited in the application see page 3, line 26 - page 7, line 26 -----	1-10



# INTERNATIONAL SEARCH REPORT

Information on patent family members

Internat. J Application No

PCT/GB 97/01667

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9322251 A	11-11-93	FR 2690438 A	29-10-93
		AU 670439 B	18-07-96
		AU 4263293 A	29-11-93
		BR 9305492 A	11-10-94
		CA 2110998 A	11-11-93
		CN 1078708 A	24-11-93
		CZ 9302865 A	19-10-94
		DE 69312857 D	11-09-97
		EP 0596088 A	11-05-94
		HR 930837 A	30-04-96
		HU 67212 A,B	28-03-95
		JP 6508600 T	29-09-94
		NO 934725 A	20-12-93
		NZ 252695 A	27-08-96
		SI 9300218 A	31-12-93
		SK 146893 A	09-11-94
		ZA 9302874 A	01-06-94
-----			
WO 8912032 A	14-12-89	AU 3765789 A	05-01-90
		CA 1338340 A	21-05-96
		US 5332699 A	26-07-94
-----			
DE 4417230 A	23-11-95	AU 2612895 A	05-12-95
		CN 1136307 A	20-11-96
		WO 9531410 A	23-11-95
		EP 0710220 A	08-05-96
		FI 960209 A	16-01-96
		HU 74107 A	28-11-96
		JP 8511760 T	10-12-96
		NO 960192 A	16-01-96
		PL 312574 A	29-04-96
		SK 4896 A	08-05-96
		ZA 9503954 A	17-01-96
-----			
WO 9315028 A	05-08-93	AT 136874 T	15-05-96
		AU 663155 B	28-09-95
		AU 3358493 A	01-09-93
		AU 5837494 A	15-08-94
		BR 9305741 A	28-01-97
		BR 9406117 A	19-03-96

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Internat J Application No

PCT/GB 97/01667

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9315028 A		CA 2154442 A	21-07-94
		CZ 9501836 A	15-05-96
		DE 69400154 D	23-05-96
		DE 69400154 T	28-11-96
		EP 0621858 A	02-11-94
		EP 0679145 A	02-11-95
		EP 0710628 A	08-05-96
		ES 2086248 T	16-06-96
		FI 943380 A	14-09-94
		WO 9415883 A	21-07-94
		GB 2277516 A,B	02-11-94
		GB 2289673 A,B	29-11-95
		JP 7502969 T	30-03-95
		JP 8506561 T	16-07-96
		NO 942655 A	14-07-94
		PL 309954 A	13-11-95
		SK 85694 A	05-01-95
		ZA 9400236 A	22-08-94
		AU 2717195 A	28-09-95
		CA 2127357 A	05-08-93
		CN 1078218 A	10-11-93
		CZ 9401700 A	14-06-95
		GB 2287934 A	04-10-95
		HU 68033 A	29-05-95
		NZ 246629 A	27-07-97
		ZA 9300311 A	23-08-93
-----			
WO 9209536 A	11-06-92	FI 93346 B	15-12-94
		AT 117662 T	15-02-95
		AU 8908791 A	25-06-92
		DE 69107091 D	09-03-95
		DE 69107091 T	17-08-95
		EP 0558548 A	08-09-93
-----			
WO 9601793 A	25-01-96	SE 504288 C	23-12-96
		AU 2939895 A	09-02-96
		EP 0768989 A	23-04-97
		FI 970016 A	06-02-97
		NO 965293 A	11-12-96
		PL 318055 A	12-05-97

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern. al Application No

PCT/GB 97/01667

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9601793 A		SE 9402405 A	08-01-96
WO 9529135 A	02-11-95	AU 2446395 A	16-11-95
		AU 6679594 A	08-11-94
		CA 2165081 A	02-11-95
		CZ 9503297 A	12-06-96
		EP 0695206 A	07-02-96
		EP 0703879 A	03-04-96
		FI 955973 A	13-12-95
		PL 312244 A	01-04-96
		SI 9520005 A	31-08-96
		SK 157395 A	08-05-96
		US 5614452 A	25-03-97